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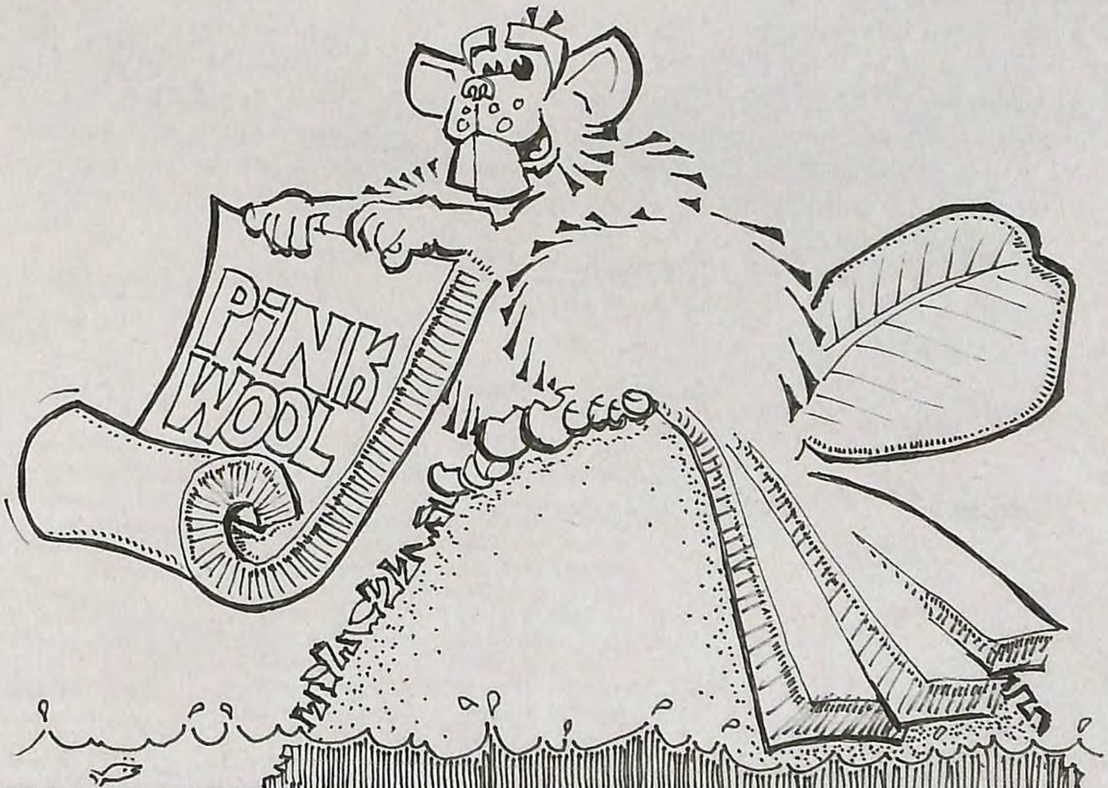
Exterior insulation



From the Editor . . .

What price are we willing to pay to maintain our health? We now know that a healthy environment is important to our health and well-being. When we build, we don't intentionally set out to create an unhealthy environment. But we are learning that in many ways we are creating a less than healthy environment in spite of appearances to the contrary.

Today we are living in the golden age of chemistry, surrounded by materials, products and even foodstuffs that are synthetically created through the intervention of chemistry. We even rely on synthetic chemicals to keep healthy when we do get sick. Yet some illnesses are the result of the industrial and commercial processes we have created.

The commercially processed foods, consumer products in our homes, and products we use to create the homes we build are the result of a long production chain that relies on a wide range of raw materials and energy inputs with more or less impact on the ecosystem. Anywhere in the world one goes today we see similar materials created by the modern-day alchemist wizards.

We are slowly becoming aware of the dark side of this new wizardry. The impact of exposure to these processes and products can be detrimental on human health, be it the smelly volatile emissions of products as they cure, or the invisible electromagnetic radiation we surround ourselves with – think cell phones, Wi-Fi and the many wireless signals surrounding us even within our homes or workplaces, or the degradation of the larger environment. The cumulative impact is not only on us as individuals, but also on the greater environment.

It's not just the products in our immediate surrounding, but also the full production and transportation chain that supports our lifestyle. It's a sad commentary on our lifestyle that a fast growing source of raw materials for the new products, which now come with eco-friendly tags (to make us feel good), is the mountain of stuff we generate and then toss into the dumpster to be replaced by newer stuff.

Pollutants know no borders, so what happens in one region or country, can impact a different corner of the planet, as images from space are showing us. We only have one planet on which we live.

The importance of a healthy environment, and its importance for human health now and into the future is becoming recognized in some countries, not only by new laws or regulations. or trying to change how business is done, but more fundamentally, as amendments to their constitutions by adding the right to a healthy environment as a fundamental human right. Even if there is uncertainty what such rights really mean, it's a step in the right direction, recognizing the importance of a healthy ecosystem.

Unfortunately, this seems to be an idea that is foreign to North America where environmental studies, laws and regulations are being watered down or eliminated, if not removed entirely from the public vocabulary.

Richard Kadulski,
Editor

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Exterior insulation – double vapour barrier?

The performance of construction assemblies can be determined by testing and by analysis. Although modelling tools have become quite sophisticated, and now are routinely used for analysis, they cannot always predict exactly what happens in the real world. That is where research projects monitoring actual conditions are important as they can offer unique insights that may not otherwise be anticipated and also provide validation for modelling tools and formulas.

A multi-year project in Coquitlam, BC was initiated by Mark Gauvin of Gauvin 2000 Construction in collaboration with Building Science Corporation in 2005. A test hut was built to permit the side-by-side comparison of seven 1.0m x 2.4m (38" x 96") test wall panels on each cardinal orientation (for a total of 28 wall test panels) and three 3.6m x 7.2m (12' x 24') roof panels on the north- and south-facing roof slopes. In this case, all of the test panels are exposed to the same indoor conditions.

The objective of the test hut was to determine the performance of historical, current and possible future wall assembly configurations under field conditions. Each wall or roof assembly is instrumented with sensors to collect the desired assembly data (e.g. moisture content, temperature relative humidity, exterior weather data, etc.) and is stored on a central data logger.

The third phase of testing (December 2009 to November 2011) simulated wetting directly against the exterior surface of the wood sheathing instead of wetting the interior of the enclosure as previously tested, while simulating typical interior wintertime relative humidity levels.

One set of test panels focused on an issue that generates much concern – the installation of low vapour permeance exterior insulation over wood sheathing. There is a commonly held perception that installing a low vapour permeance exterior insulation, such as extruded polystyrene, over wood sheathing, will result in moisture issues that will deteriorate the wood-based structural sheathing. This perception is important to address because installing exterior insulation will become more prevalent with the changing building codes, and requirements for continuous insulation.

The performance of an exterior insulated wood-framed residential wall on all four cardinal orientations was compared to the performance of two other wall systems. The construction is summarized in the table below.

Wall 7 had 1½" extruded polystyrene insulation on the exterior, and a vapour barrier paint interior vapour barrier. Wall 5 is representative of typical current construction practices in Vancouver - stucco cladding on a ventilated and drained rain screen. The second wall for comparison (Wall 2) is a more common wall (although no longer code-approved in Vancouver) with direct applied ¾" stucco on one layer of 30 minute building paper.

The interior temperature was kept at approximately 20°C for the entirety of the monitoring period, with some small variations. The interior relative humidity was set to 40% for the winter months and maintained with a humidifier controlled by the data acquisition system. The temperature and relative humidity are used to calculate the hourly dew point of the interior air, for comparison to the sheathing temperature.

Sheathing moisture content was measured – it is used as the performance criteria because this is the first location where vapour diffusion condensation would occur during the heating season.

Construction of wall panels tested

Wall 7	Wall 5	Wall 2
2x6 wall, R-20 fiberglass batt interior vapour barrier - latex paint on the drywall ½" OSB exterior sheathing Tyvek housewrap **1 ½" XPS insulation on exterior** stucco cladding on Drainwrap capillary break	2x6 wall, R-20 fiberglass batt 6 mil poly vapour barrier ½" OSB exterior sheathing 2 – 30 minute sheathing paper **¾" rain screen** strapping stucco cladding	2x6 wall, R-20 fiberglass batt 6 mil poly vapour barrier ½" OSB exterior sheathing 1 layer 30 minute sheathing paper stucco cladding directly applied (***no rain screen***)

The degree of potential risk in terms of vapour diffusion and air leakage moisture condensation is proportional to the length of time that the sheathing temperature is continuously below the dew point without any drying potential, and the magnitude of the difference between the dew point and the sheathing temperature. This means that a sheathing temperature 10° below the dew point will condense more water than a sheathing temperature 2° below the dew-point, all other factors being equal. If the temperature of the sheathing is below freezing, condensation will occur as frost or ice, and then melt when the sheathing temperature increases.

In the case of these test walls, the most significant moisture risks were at the locations where water was being introduced. The condensation potential is directly related to the interior conditions and the sheathing temperature. Generally speaking, dry air has less moisture available to condense, so there will be less concern for lower humidity interior conditions.

Under normal conditions, if the peak sheathing moisture content is less than 20% there will be no mould growth, and there is very little risk in the assembly.

If the peak sheathing moisture content reaches between 20% and 28% there is a potential for mould growth, depending on frequency and length of wetting and temperatures during wetting. Assemblies that see these conditions can still be successful but conservative assessments usually require corrective action be taken.

If the peak sheathing moisture content exceeds 28% then moisture related problems can be expected. Assemblies with this kind of design should be avoided.

The predicted moisture content should be kept in context and good scientific judgment is required to determine the moisture risk to the sheathing. For example, higher wood moisture contents in the cold winter months when the wood is on the cold side of the assembly are much safer from a mould growth perspective than similar moisture contents in the summer, when the temperatures are in the correct range for optimal mould growth.

Table 2

Drying after intentional wetting in January		
	Wall 2 (direct applied stucco)	Wall 7 (exterior XPS insulation)
North	>106 days	68 days
East	>106 days	53 days
South	68 days	29 days
West	95 days	47 days
Days until measured content dropped to 20% MC		

High moisture content for a short period followed by drying is not necessarily risky, as wood framed structures are able to manage high moisture contents for short periods without exceeding the safe storage capacity of the assembly. The safe storage capacity is the amount of moisture an assembly is able to manage without suffering any moisture related issues.

The baseline wood moisture content is a factor in the safe storage capacity since the lower the wood moisture content is during normal operation (without wetting events), the more moisture the wood can handle before reaching any durability risks. If the measured wood moisture content is consistently higher, even if there are no moisture durability risks, there is less moisture buffering capacity in the wood before reaching moisture related durability risk levels.

The monitored results at the Coquitlam test hut showed that there is a significant decrease in the potential of air leakage condensation when 38mm (1½") of XPS is installed as exterior insulation.

Table 3 summarizes the total number of hours of potential air leakage condensation, which is a measure of the moisture related durability risk.

Conclusions

Following the interior wetting events, both Wall 5 and Wall 7 on the east and west sides dried similarly. When wetting took place from the exterior, Wall 5 dried more quickly than Wall 7. The moisture content of the sheathing showed no significant differences between Wall 5 and Wall 7.

Using a dew point analysis, Wall 5 had a much higher moisture durability risk with respect to interior air leakage condensation than Wall 7. This is not a durability problem unless interior air reaches the surface of the sheathing. During the deconstruction, the OSB surfaces of Walls 5 and 7 both appeared to be in good condition, with very little staining only around the point where wetting was introduced, although Wall 7 did appear a little more pristine overall than Wall 5.

Moisture monitoring of the sheathing showed that the sheathing moisture content of Wall 2 was always higher than Wall 7, but did not exceed criteria for moisture related durability concerns. Following the wetting from the interior, Wall 7 dried more quickly to safe levels than Wall 2 because the vapour barrier on Wall 7 was a vapour barrier paint which has a small amount of drying potential, while the vapour barrier layer on Wall 2 was polyethylene which has no potential to allow drying to the interior.

Following the exterior wetting, the drying rates were relatively similar between walls 2 and 7. Generally the moisture content was higher on Wall 2, so even though the drying rates were similar, the moisture content of the sheathing on Wall 2 remained elevated compared to Wall 7.

On the north orientation, the exterior of the OSB on Wall 2 was quite dark and stained, especially in the vicinity of the wetting point. On the other hand, walls 5 and 7 on the north orientation appeared to be in pristine condition. Only the area immediately behind the wetting point was a little darker on Wall 7 than Wall 5, corresponding to the measured quicker drying rate of Wall 5, likely due to ventilation drying of the rain screen. However, overall the rest of the North Wall 7 was marginally better than North Wall 5.

In dew point analysis, Wall 2 had significantly higher moisture durability risks with respect to interior air leakage condensation than Wall 7. This is because the exterior insulation in Wall 7 keeps the sheathing at a higher temperature, reducing the number of hours that the sheathing is below the interior air dew point. This is not a durability problem unless interior air reaches the surface of the sheathing

Observations from the wall deconstruction showed that the exterior surface of the OSB for Wall 2 was quite stained behind and around the wetting apparatus.

Table 3

	Potential Hours of Condensation	
	Dec 18, 2010 to May 30, 2010 (total 3936 hours)	Sept 19, 2010 to March 23, 2011 (total 4441 hours)
Wall 7 (XPS on exterior)		
North	91	551
East	72	478
South	51	320
West	94	518
Wall 5 (rain screen)		
East	519	1879
West	716	1680
Wall 2		
North	1252	2417
East	1165	2293
South	1050	1980
West	741	2011

There was also staining on the upper portion of the OSB on Wall 2, as well as a general overall darker appearance to the entire OSB sheet compared to Wall 7. The OSB on Wall 7 looked like new except directly behind and under the wetting apparatus.

The net result of the testing after thorough data analysis and wall deconstruction is that **there are no moisture related durability concerns with the wood structural sheathing when 1 ½" of extruded polystyrene insulation is installed on the exterior.**☼

Vancouver Field Exposure Facility: Phase III Exterior Insulation Analysis *Research Report – 1207, Building Science Corporation*
By Jonathan Smegal, MASc; Joseph Lstiburek, PhD; P.Eng John Straube, PhD, P.Eng; Aaron Grin, MASc
www.buildingscience.com

Vapour Barriers and Building Durability

The function of a vapour barrier is to control the water vapour *diffusion* to reduce the occurrence or intensity of condensation. It has one performance requirement: it must have the desired vapour permeance and be installed to cover most of the area of the building envelope. If there is a small gap or imperfection, its performance is not substantially reduced and can be accepted in practice.

On the other hand, air barriers control the airflow, and thus the vapour transport by convective airflow. The building code requires an air barrier in all building enclosures, which provides not only reduced moisture flow, but also increased comfort, reduced energy consumption, control of odours and pollutants and sound transmission.

The building code also requires vapour diffusion control, referred to as vapour barriers. The code definition of vapour barrier is a material with a permeance no greater than 60 ng/Pa.s.m² (or 1 perm) on the warm side of the dew point of the assembly.

The number defining what qualifies as a vapour barrier is arbitrary. Studies have shown that

such a low level of vapour permeance on the interior is not needed, because vapour diffusion moisture movement is very small compared to airflow. It is the air barrier that is much more important.

Some codes have changed the terminology to *vapour diffusion retarder* rather than *vapour barrier* because it better describes the function. Values of vapour permeance in the range of 300 ng/Pa.s.m^2 (or 5 perms) are used as the maximum permeance for a vapour diffusion retarder. From a technical point, in most cases a material with a vapour permeance of 100 or 200 ng/Pa.s.m^2 will perform equally well to a material with a permeance of 60 ng/Pa.s.m^2 or less.

Calculation of moisture flow by vapour diffusion is typically done using simple, one-dimensional analysis of temperature gradients across an assembly. However, this is not an accurate way to do it, because vapour permeability can vary with temperature and moisture content of the materials. The moisture storage capacity of most materials is quite high, so steady state conditions (assumed by the simple calculations) almost never happen in reality.

One reason that older buildings were so durable is that although they were not airtight, when they got wet they didn't stay wet very long. Repeated wetting followed by repeated drying was never a problem. Older buildings got wet but they dried quickly because of the massive heat loss from the building.

With increased levels of insulation, we have reduced the drying potential of the building enclosure. Cold outer surfaces are wetter because the relative humidity at the surface is much higher and most materials in the assembly are hygroscopic. We have largely switched from plywood to OSB exterior sheathing, which means a large reduction in the breathability of the assembly. In addition, we are now starting to use insulating sheathings made out of impermeable foam.

The reduced water vapour permeability of the enclosure on the inside means that there is a huge reduction in the water vapour transmission to the inside, especially since we use polyethylene vapour barriers and vinyl wall coverings. With new highly insulated building enclosure designs, we are now seeing materials on the outside that have low permeability and don't readily breathe (i.e. allow vapour diffusion) creating conditions that make it difficult for an assembly to dry. ☼

You Asked Us About: Vapour Barrier Paint

We have been building Built Green platinum homes for a number of years, and often we use the airtight drywall approach without any issues being raised by building inspectors. We are now entering a new nearby market where the inspectors do not seem to have come across the use of vapour barrier paint and gasketed drywall. They are reluctant to let us proceed without seeing poly in the home.

Can you help us or direct us to a source of information?

KB, Vernon, BC

The airtight drywall approach is one recognized approach to dealing with heat, air and moisture control in buildings. It is technically sound, code compliant and some building envelope consultants and building scientists suggest it is the superior way to build (compared to polyethylene air/vapour barrier).

There are numerous documents on the subject, but two that come with local credibility are the *CHBA Builder Manual* and the *Building Envelope Guide for Houses* by the Homeowner Protection Office.

The *CHBA Builder Manual* has a chapter dealing with various construction systems. Airtight drywall is one of four options that are described with typical common construction details.

The HPO's *Building Envelope Guide for Houses* contains a whole section of airtight drywall air barrier details. Rather than just presenting a typical construction drawing, the details are presented with a 4-D approach, showing how the detail is built-up step by step.

The *CHBA Builder Manual* is available from the association at *www.chba.ca*, and the *Building Envelope Guide for Houses* is available from the HPO at *www.hpo.bc.ca.*

Spray Foam Insulation Properties

Spray foam insulation is increasingly being used in housing. It offers a good, effective insulation strategy and can assist in achieving a more airtight building. The solid, cellular structure of foam insulation offers an insulation product that, unlike fibrous insulation materials, eliminates potential convection currents within the insulation assembly.

There are two main types of foam insulation used in construction: an open-cell (half-pound) foam, and closed cell (two-pound) foam. Both are polyurethane-based, but each manufacturer tweaks their formulas.

Open-Cell (Half-pound) Spray Foam

Half-pound insulation forms a spongy mass, soft to the touch and compressible if pressure is applied. It is a cream colour. It has a high coefficient of expansion (100:1) when being installed. The blowing process sets in motion the foaming process, and the cells created are filled with air.

Half-pound foam is airtight and qualifies as an air barrier material as it adheres to most construction materials. On expansion, it creates a blanket of tiny air cells as it fills building cavities and cracks. Excess material is easily trimmed off leaving a surface ready for interior finishes. However, it is vapour permeable, so a vapour diffusion retarder is still required. Typically, the vapour barrier used is a vapour barrier paint (which is a low-permeance drywall primer) applied directly to the foam. If the drywall is in close proximity to the surface of the foam, it could be applied on the drywall.

The R-value of half-pound spray foam insulation is 3.6 to 3.8/inch thickness and can be installed to any thickness required. When it is installed, there are few significant limitations on the amount of insulation that can be applied in one pass. If 10" of insulation is required to fill the full depth of a 2x10 joist cavity, it can be done at one time. However, if the blowing is not done properly, there could be some voids in the foam, lowering its insulation value.

Half-pound foam can be applied in sub-zero temperatures (some as low as -20°C) but the manufacturer will provide specifications for appropriate temperature limits for their product. The raw materials have a 6-month shelf life (the barrels are date labelled). Out-of-date chemicals are not acceptable, and if they are seen on a job site they should be rejected on the spot.

There are several manufacturers of half-pound foam, and although each touts the unique merits of their product, all have substantially similar properties. A new product standard is being finalized (CAN/ULC S712.1 & S712.2) so it is not yet referenced by the National Building Code. Most code authorities will look for CCMC product listings, and products on the Canadian market have listings.

The half-pound foam products generally do not absorb moisture, so they allow water to pass through the material. However, the small cavities within the material will keep a fair amount of moisture entrained within the material, and will make it slow to dry out, with the potential of maintaining conditions in the assembly that could lead to moisture-induced deterioration before drying could occur.

Closed-cell (Two-pound) Spray Foam

Two-pound insulation, also known as medium density foam insulation, is a closed-cell mass hard to the touch, resembling extruded polystyrene foam boards in feel. It is often used in larger commercial buildings, where it provides not only insulation but also is a key element in the air barrier system. The low air permeability qualifies it as an air barrier material.

Two-pound foam is vapour impermeable – the vapour permeance of 50 mm (2") of medium density foam is around 40 ng/Pa.s.m^2 so it satisfies the vapour barrier criteria of the National Building Code.

Like half-pound foam, the raw materials have a 6-month shelf life (the barrels are date labelled). Out-of-date chemicals are not acceptable, and if they are seen on a job site they should be rejected on the spot.

When it is installed, a gas is used in the foaming process and this is what contributes to the

Medium Density (Two-Pound) Spray Foam Insulation LTTR values

Product	LTTR R-value *(50 mm)*	CCMC #	Vapour Permeance *(ng/Pa.s.m²)*	Colour	Min. Application temperature
CertaSpray (Certainteed Corp)	10.2 (RSI 1.8)	13405-L	<60	Beige	5°C
JM Corbond III (Corbond Corp)	10.2 (RSI 1.8)	13476-I	49	Grey	-4°C
EcoBay CC CAN (Bayer Material Science)	11.4 (RSI 2.0) *(100mm RSI 4.2; R 24)**	13359-L	40	Teal	10°C (cold weather formulation 0°C)
Foam Lok FL-2000; Insul-Barrier BIO; GuardFoam 55 C; HTS Efficiency Max (LaPolla Industries)	10.2 (RSI 1.8)	13414-L	40	Orange	10°C (cold weather formulation -6°C)
Foamsulate Eco (Premium Spray Products Canada)	11.4 (RSI 2.0) *(100mm RSI 4.1; R 23.6)**	13527-L	58	Georgian Pine	
Heat Lok Soya, PolarFoam Soya, Airmetic (Demilec)	11.5 (RSI 2.02)	13244-L	37	Green; (Polar Foam Soya is Peach)	- 10°C cold weather formulation
Icynene MD-C-200 (Icynene)	11.0 (RSI 1.94)	13561-L	36	Silver	10°C (cold weather formulation -5°C)
Styrofoam SPF CA (Dow Chemical)	10.8 (RSI 1.9) *(100mm RSI 4; R 22.7)**	13501-L	51	Blue	-1°C
SWD Quik-Shield 112 (SWD Urethane Co)	10.4 (RSI 1.83)	13555-L		Pearl grey	-2.2°C (cold weather formulation -9.4°C)
Walltite Eco v.3 (BASF Canada)	12.15 (RSI 2.14) *(100mm RSI 4.55; R 25.8)**	13588-L	41	Purple	10°C (cold weather formulation -10°C)

**Manufacturer published LTTR data*

Data for this table was assembled from CCMC reports and Manufacturer's technical data sheets.

higher insulation values of two-pound foam. Because the chemical reaction is exothermic (giving off a considerable amount of heat) it must be installed in 50 mm (2") lifts, and no more than 100 mm (4") can be installed in one day. Fires have been caused by overzealous applicators installing large volumes in a confined space.

Two-pound foam must not be applied when temperatures are below 0°C, although some manufacturers have special cold weather formulations to allow applications as cold as -10°C.

There are a number of medium density foam products, and although each manufacturer touts the unique merits of their product, all have substantially similar properties, except for R-values that are not consistent (see table) because each producer tweaks their formulations. The applicable product standard is CAN/ULC S705.1 which has been referenced in the National Building Code since 1988 as an appropriate insulation material. The standard also requires that application be done by licensed applicators. The application protocol is outlined in CAN/ULC S705.2. Medium density foam products also have CCMC product listings.

The R-value of medium density foam insulation creates confusion, and installers often use the confusion to their advantage and deceive unsuspecting customers. Medium density foam has higher R-values than most other insulation products, but they can be (and are) overstated. The issue is that some of the gas used as a blowing agent for foaming the foam (which gives it the higher insulation properties) leaks out of the material thus lowering the overall R-value. The leakage does stabilize, but will mean a

lower R-value over time. This differs from more traditional insulation materials such as fibreglass or loose fill cellulose, which are tested at a given condition, only have air in the space, and see no change in their R-value.

In addition, because the medium density foam is applied in multiple layers, the R-value can increase with material thickness. Some manufacturers have test data showing this, and may show the values in their product data sheets.

There are three test conditions for medium density spray foam. The ASTM C518 test protocol provides an initial value and another value after the sample has been conditioned for 90 days. This second value is sometimes referred to as long term R-value. However, 90 days is not a reasonable long-term test, as there can still be degradation of the insulation propertied. That is why CAN/ULC S705.1 has a Long Term Thermal Resistance (LTTR) value to reflect in-service conditions.

In the United States, the common practice is to refer to the R-values derived using the ASTM test protocols, which generate the higher R-values, but these are not acceptable in Canada, where the CAN/ULC S705.1 LTTR values must be used. When checking for product R-value on the Internet, it is important to ensure that appropriate data is used from the manufacturer's Canadian web site. We have noticed that different values appear on US web sites where LTTR values are not used. ☼

Spray Foam Insulation in Un-vented Roofs

Spray foam insulation can be used in un-vented roof applications, where the foam insulation is installed directly against the roof sheathing. The intent of ventilation requirements in the building code is to minimize condensation that may occur on the underside of the roof sheathing because of any moisture driven by air leakage. Roof ventilation above the insulation in a leaky ceiling assembly can draw warm moist air from the interior through air leakage in the building envelope thus contributing to moisture problems.

Air leakage has been identified as the principal carrier of moisture that can lead to deterioration, and is acknowledged in the code's Appendix notes which state that controlling the flow of moisture by air leakage and vapour diffusion into attic or roof spaces is necessary to limit moisture-induced deterioration. However, because of imperfections in the air and vapour barriers systems, venting of attic or roof spaces is generally still required.

The code does have an exception (in 9.19.1.1) that recognizes that some ceiling-roof assemblies such as those used in some factory-built buildings have demonstrated that their construction is sufficiently tight to prevent excessive moisture accumulation, and ventilation would not be required. One such assembly is an un-vented roof deck assembly, insulated with spray-in-place foam insulation.

The Ontario Building Code issued a branch opinion a number of years ago that, where a roof assembly is insulated with rigid insulation without any gaps or voids, such as with spray foam insulation, then the venting is not necessary.

Recently, the BC Building Code Appeal Board ruled on the concept of un-vented roof assemblies. It determined that the code permits an un-vented roof assembly where venting can be shown not to be necessary. It stated that "*the Board considers that sufficient information is available from various sources to demonstrate to a building official that venting is not necessary with this type of roof assembly due largely to its inherent air-tightness. It needs to be clarified that 60 ng/(Pa.s.m²) refers to vapour permeance and is not a measure of air tightness.*" ☼

Protection of Foam Insulation

All foam products must be protected by a thermal barrier consisting of ½" gypsum board, lath and plaster, or masonry or concrete not less than 25 mm thick. The protection must be continuous and keep the foam insulation from exposure to the interior of the building. However, penetrations of the protection for such minor items as electrical outlets and fixtures, sprinkler piping, mechanical vents and other minor electrical and mechanical penetrations are acceptable.

The penetrant and associated fittings and seals will prevent the small amount of foamed plastic insulation surrounding the penetration from being exposed to the interior of the building.

Foam insulation in crawlspaces and attics not normally accessible doesn't need to have thermal protection, provided that the space is kept isolated from the remainder of the interior space.

Canadian Home Builders' Association

Technical Research Committee News

National Building Code Update

Revisions and Errata to the 2010 National Building Code have been issued. These include the new energy efficiency requirements which are now part 9.36 of the National Building Code.

BC is expected to adopt most of 9.36 later this year; several other provinces are likely to follow.

Other revisions and errata are also available for the 2010 National Fire Code of Canada, 2010 National Plumbing Code of Canada, and for the structural commentaries to the User's Guide to the 2010 National Building Code of Canada.

Copies or the changes can be downloaded, free of charge, from the NRC Web site *www.nationalcodes.nrc.gc.ca.*

Bruce Clemmensen Appointed to the Order of Canada

Bruce Clemmensen, former TRC chairman, and former CHBA president, has been appointed to the Order of Canada for his work in the renewal of building and fire codes. The Order of Canada is Canada's highest civilian honour established to recognize a lifetime of outstanding achievement, dedication to community and service to the nation.

Bruce Clemmensen chaired the Canadian Commission on Building and Fire Codes (CCBFC) from 1997 to 2010. He guided the commission at a time when the codes were undergoing a major change – from being largely prescriptive documents to ones based upon clearly stated objectives. The resulting 2005 National Model Construction Codes provided greatly expanded information that clearly stated the scope and purpose of requirements and made them easier to use when proposing or evaluating "alternative solutions." He also guided the commission in establishing a strong partnership between the provinces and territories and the national model construction code development system.

How Have New Homes Changed?

The performance of buildings, automobiles, and other equipment has improved over the past half-century. Canadian housing has improved significantly over the past 40 years, and there is a perception that other equipment has improved equally. Although technology has changed and advanced over the years, it is interesting to see what the real impact is.

Although there is information about changes in new housing stock, it doesn't really show what that means to an individual house, since home energy performance is a moving target as homeowners renovate and upgrade or otherwise change their home.

CHBA did an analysis to compare the performance improvements of automobiles and new homes over the past forty years. The analysis compared old and new homes, based on the 'as built', rather than 'as found' specifications. They looked at a typical 1973 two-storey Ottawa home with a floor area of 2,100 sq.ft. The "as-built" specifications were taken from CMHC/HUDAC costing studies of that time. The contemporary home specifications were essentially the 2012 Ontario Building Code, and were compared to the 2012 R-2000 Standard. Only the envelope and mechanical specifications were altered to those 'typical' of new construction in each period.

The house performance data was generated using HOT2000 v.10.51

A review of the ecoEnergy database found that the equivalent typical 1973 Ottawa house design had been improved by homeowners over the years. When built in 1973, it would have an ERS rating of about 41. The "as found" condition for the same type of house (before any ecoEnergy improvements) was an average ERS of 63, and when improved it rated an average ERS of 72.

The CHBA analysis showed that the home energy performance (total annual energy consumption) for the home, as built, has been reduced from 343.2 GJ/year in 1973 to 116.8 GJ/year (and 76.8 GJ/year for the home if built to the 2012 R-2000 Standard). This is equivalent to an EnerGuide (ERS) rating of 41 in 1973, and moving to ERS of 79 for the 2012 Code built house. This represents a decrease in total energy consumption of 66%.

The comparison automobile was more challenging because most vehicle models have changed, and many are no longer in production. One of the few models still in production is GM's Chevrolet Impala, so a 1969 Chevy Impala was compared to a 2012 Chevy Impala.

The US EPA fuel efficiency rating (mpg/ US gallons) for the 1969 Chevrolet Impala was 19 mpg, and the 2012 model improved to 22 mpg, for a total increase of 15.8% in 'combined' fuel efficiency. Other vehicles in the EPA listings with models going back to the late 1970s, such as the Ford Mustang, Honda Accord, and Toyota Corolla showed an improvement of 1 mpg.

Heat Pump Water Heater

Domestic water heaters are the biggest energy users in Canadian households behind space heating systems.

Energy consumption reduction can be achieved using a heat pump, which extracts heat from one place and transfers it to another. Heat pump technology has been around for many years, and is commonly used for air conditioning (cooling). We don't think of refrigerators, but they are the most common example of a heat pump that's been in our homes for several generations now. Heat pumps are now increasingly being used for space heating of homes.

Heat pumps transfer heat by circulating a refrigerant through a cycle of evaporation and condensation between two heat exchanger coils. In one coil, the refrigerant is evaporated at low pressure and absorbs heat from its surroundings. The refrigerant is then compressed on the way to the other coil, where it condenses at high pressure. At this point, it releases the heat it absorbed earlier in the cycle.

A newer application that has been used in some areas for a few years, but is now being marketed widely, combines a heat pump unit with a traditional electric hot water tank.

The GeoSpring™ hybrid water heater by GE has been designed with maximum energy efficiency in mind. The tank portion of this water heater includes two electric heating elements, a pressure relief valve, an internal porcelain-lined tank and an anode rod. The top of the tank houses the heat pump module. This process creates the same amount of hot water as a traditional water heater, but according to GE it can reduce household water heater expenses up to 62%.

The compressor and evaporator are integrated into the unit to take in ambient heat from the air surrounding the tank location. Coils wrap the tank all the way to the bottom to transfer this heat into the tank and heat the water. This has the effect of providing the same amount of water as a traditional water heater, but reducing the amount of electricity used for water heating.

The GeoSpring™ unit is a 50-gallon tank that provides the same hot water recovery as traditional 50-gallon standard electric tank water heater. It has four operating modes: heat pump mode; hybrid mode (operating heat pump and electric elements simultaneously); boost mode (similar to the hybrid but allowing the system to prepare for high water loads); and vacation mode which allows the system to drop water temperature to 10°C (50°F).

The water heater pulls the heat out of the air in the home to heat the water. This does add a small load on the space heating system. If the heat pump water heater is located in an area that may be subject to overheating, such as the kitchen, mechanical room, or adjacent to home electronic hubs, it can take advantage of the localized excess heat and may help reduce overheating. Thus it could decrease the load during summer cooling months (where cooling is installed in a home) but will add to the space-heating load in the winter. However, the full impact will depend on a number of factors, including the design of the house, the occupant lifestyle, the location of the water heater, and ground water temperature.

Where electric water heaters must be used, then a heat pump water heater is an option that should be considered.

Information: *www.geappliances.ca*, look for water heaters.

R-2000 Net Zero Energy Pilot

New construction standards are moving toward net zero energy construction – in other words buildings with zero net energy consumption and zero carbon emissions on an annual basis. Around the world there are numerous initiatives underway – many are still demonstrations of what can be done. CMHC's recently completed Equilibrium demonstration project was one such example.

Early in 2013, Natural Resources Canada will be announcing the R-2000 Net Zero Energy pilot which will aim to recognize the builders and homes reaching net zero energy performance in Canada, and to pilot the next generation of NRCan's R-2000 Standard and EnerGuide Rating System in net zero energy applications.

The intent of the R-2000 Net Zero Energy Pilot is to draw on the national systems and infrastructure developed by NRCan – including the certified energy advisors, certification process and quality assurance protocols – which will provide recognized metrics, objectivity, standardization and credibility to this emerging direction.

The R-2000 Standard will be the basis for the pilot. The minimum building envelope requirements of the 2014 R-2000 Standard will be applied to ensure that the envelope and other long-term elements are addressed before renewable energy technologies are used to reduce conventional energy use. The R-2000 builder community has long been the group of experts advancing energy innovation in home building, so the intent is that this pilot, along with the next generation standards, will help to reinvigorate this community of leaders.

The pilot will label houses with a next generation EnerGuide (ERS) rating that is based on energy consumption under standardized conditions, rather than an arbitrary number on a scale of 0 to 100. Thus a net zero energy house will be rated as 0 GJ. This will offer an opportunity for participants to use and feed into the next generation ERS process to ensure it addresses any outstanding issues that relate to net zero energy homes. The next generation ERS also includes an add-on service called the Efficient Living Assessment, which is a post-occupancy assessment that can be used to confirm as-operated performance.

Thanks to R-2000 certification, quality assurance will be provided for builders and homes that are attaining net zero energy home levels of performance. Each participating house will need to meet the established R-2000 and ERS criteria for the pilot and be certified and labelled accordingly. Using R-2000 and ERS avoids marketplace confusion in green labelling and provides continuity with the over one million Canadian homes that have been labelled using ERS to date.

Non-R-2000 builders will be able to get involved with the pilot and to use the house to become R-2000 builders.

The objective of the pilot is to advance the commoditization of net zero energy homes, so there will be a focus on off-the-shelf technology in homes that can be built today using technologies already available on the market and that meet industry standards and regulations. Technologies will be limited to pre-engineered products and systems (e.g. not relying on custom mechanical systems). This will help ensure that the technologies can be modelled and provide some assurance with regard to their long-term performance.

With the draft 2014 R-2000 Standard and the next generation ERS as the basis, NRCan will examine the best means for seamlessly incorporating the net zero energy offering into its suite of standards on a permanent basis moving forward. NRCan will also use this opportunity to explore possibilities surrounding net zero energy ready homes. Using R-2000 and ERS avoids marketplace confusion in green labelling and provides continuity with the over one million Canadian homes that have been labelled using ERS to date.

However, NRCan will not be allocating any financial resources towards pilot participants but will offer technical support and promotion as an in-kind contribution. Participants will benefit from gaining insight into design of homes using available, high performance building envelope products, technologies, and techniques that can be used to achieve net zero energy performance.

More details are to be formally announced in the spring of 2013. Builders will be asked for expression of interest by asking for submissions of an initial concept/design and response to pilot criteria for proposed pilot homes, with a hoped for start of construction of the first homes in the fall of 2013. Help will be provided with design and modelling. On completion of the house, an "as-operated" assessment will be done, using a new *ERS Efficient Living Assessment* to obtain as-operated energy performance after occupants have moved in.

Following conclusion of the pilot, lessons learned from the pilot will be made available to stakeholders interested in net zero energy home performance, and may be incorporated into the R-2000 Standard, possibly adding a R-2000 Net Zero Ready or R-2000 Net Zero recognition.

Energy Answers

Rob Dumont

Do you see the need for a new energy performance standard for houses that is more stringent than the EQuilibrium (Net Zero Energy) Standard?

Yes. The time is right. In 2012 we had another year of rising carbon dioxide levels, warmer oceans, declining Arctic and Antarctic ice levels, typhoons, hurricanes, and the "Frankenstorm" that accompanied Hurricane Sandy in the Northeastern U.S. Fossil fuel burning is the chief culprit.

Buildings account for about 40% of society's energy use in North America. A sustainable world will not exist without sustainable buildings.

Keith Hanson, an engineer in Saskatoon with many years involvement with housing innovation, has described housing innovation as being similar to a railroad train. At the front of the train are the locomotives, the innovative designs that propel the train. In the middle are the "code" houses. At the rear are the cabooses and obsolete houses that have reached the end of their useful life. Over time the codes become more stringent as energy prices and environmental damage increase.

We now have a number of EQ houses in Canada that have achieved Net Zero Energy performance over the period of a year. In Figure1 a photo is shown of the Ryan and Pam Jansen Residence near Saskatoon, which has achieved annual net zero energy use. The house consumed 14,300 kWh over a one-year monitoring period, and also produced 14,300 kWh. The owners have done the right things—superinsulation, passive solar design, thermal mass, air sealing, heat recovery ventilator, heat pump and efficient lights and appliances and photovoltaics.

Saskatoon is located at 52 degrees north latitude. It is not an easy location to achieve Net Zero. Less than 1% of the world's population live in as cold a climate.

I propose a new standard. This new standard would address not only energy use in the home, but also transportation issues for the occupants. The average car in North America travels about 20,000 km per year. To supply this energy for a modest sized electric vehicle, about 5,000 kilowatt-hours a year would be needed.Cars are ubiquitous in North America. 92%of households in the U.S. own a car, according to data from the U.S. Dept. Of Transportation. It is time to address transportation energy.

What would you call the new residential energy standard?

SUSTAINA +5 is my choice. The SUSTAINA speaks for itself, but the +5 refers to +5 megawatt-hours, or 5,000 kilowatt-hours a year. 5 Megawatt-hours a year would be enough to power an efficient electric car over a typical distance of 20,000 km a year. The 5 MW-h should be supplied by on-site energy sources such as photovoltaics or wind energy.

2013 will mark the 40th anniversary of the 1973 oil shock when world oil prices rose dramatically from about $3 to $12 a barrel. In response, the first really energy efficient space heating houses such as the Saskatchewan Conservation House in Regina and the Zero Energy House in Denmark were developed. Space heating was the biggest load at the time. Over time significant improvements have been made in window technology, heat recovery ventilators, air sealing, appliance efficiency, lighting (compact fluorescent lamps and light emitting diode lamps) and photovoltaics. These developments will continue, but even at the current state of development the technologies are there that can make the SUSTAINA +5 Standard achievable.

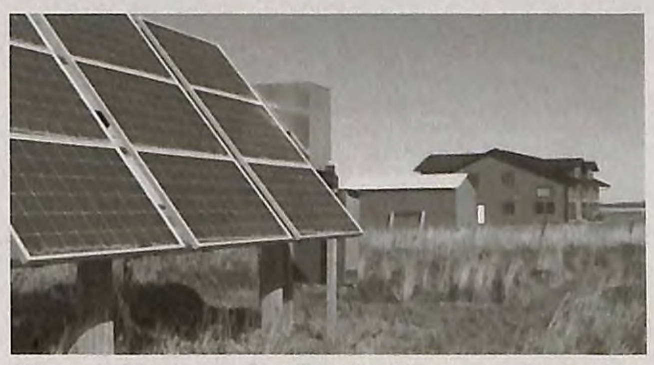

Figure 1. The Jansen Net Zero Residence near Saskatoon. Only part of the PV panels, which are ground mounted, are shown in the photo.

CMHC Information Products Disappearing

The cutbacks at the CMHC are continuing, with repercussions for Canadian housing – not just for industry but also for homeowners.

A series of consumer publications dealing with healthy home environment issues have been pulled – staff were instructed that existing stocks were no longer to be marketed, distributed or sold, and remaining stock were to be sent to recycling. All related information has been removed from the CMHC Web site.

Two French and three English copies of the publications will be available for loan at the Canadian Housing Information Centre in Ottawa, but if their existence is buried in a library database, one wonders if anyone is going to know about them, other than someone doing academic research.

It is not entirely clear what the rationale was for such a drastic sudden action – normally one would at least expect that existing stocks would have been allowed to be depleted by normal product distribution. Removing all mention of the existence of the material smacks of someone trying to cover something up.

Included in the list of titles pulled was *Radon: A Guide for Canadian Homeowners*. This document was an excellent consumer piece about radon, and had been updated in 2007.

Other items discontinued:

- About Your House: How to Reduce Chemical Contaminants in Your Home
- About Your House: Should You Test the Air in Your Home for Mold?
- About Your House: Water Damage, Mold and House Insurance
- Radon: A Guide for Canadian Homeowners
- Clean Air Guide: How to Identify and Correct Indoor Air Problems in Your Home
- Clean-Up Procedures for Mold in Houses
- Newcomer's Guide to Canadian Housing
- Nine Healthy Housing Fact Sheets on Additions, Attics, Basements, Bathrooms, Exteriors, Interiors, Kitchens, Landscapes, Mechanicals

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